METRO THERMAL ASH MONOFILL CLOSURE CAP

STORMWATER DAMAGE AND RESTORATION UPDATE

SMITH+GARDNER

Metro Nashville PUBLIC WORKS

Presented at the

45th ANNUAL ENVIRONMENTAL SHOW OF THE SOUTH CONFERENCE & EXHIBITION

April 20-22, 2016

Gatlinburg, Tennessee

Presenters:

John M. Gardner, P.E.

Clayton Hand, P.E.

RESOURCE MANAGEMENT SMITH+GARDNER 25 1991-2016 REMEDIATION RECOVERY

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Metro Thermal Ash Monofill

- **Located in Downtown Nashville along Cumberland River**
- **Closed in October 2004**
- **Total Footprint 15 acres**

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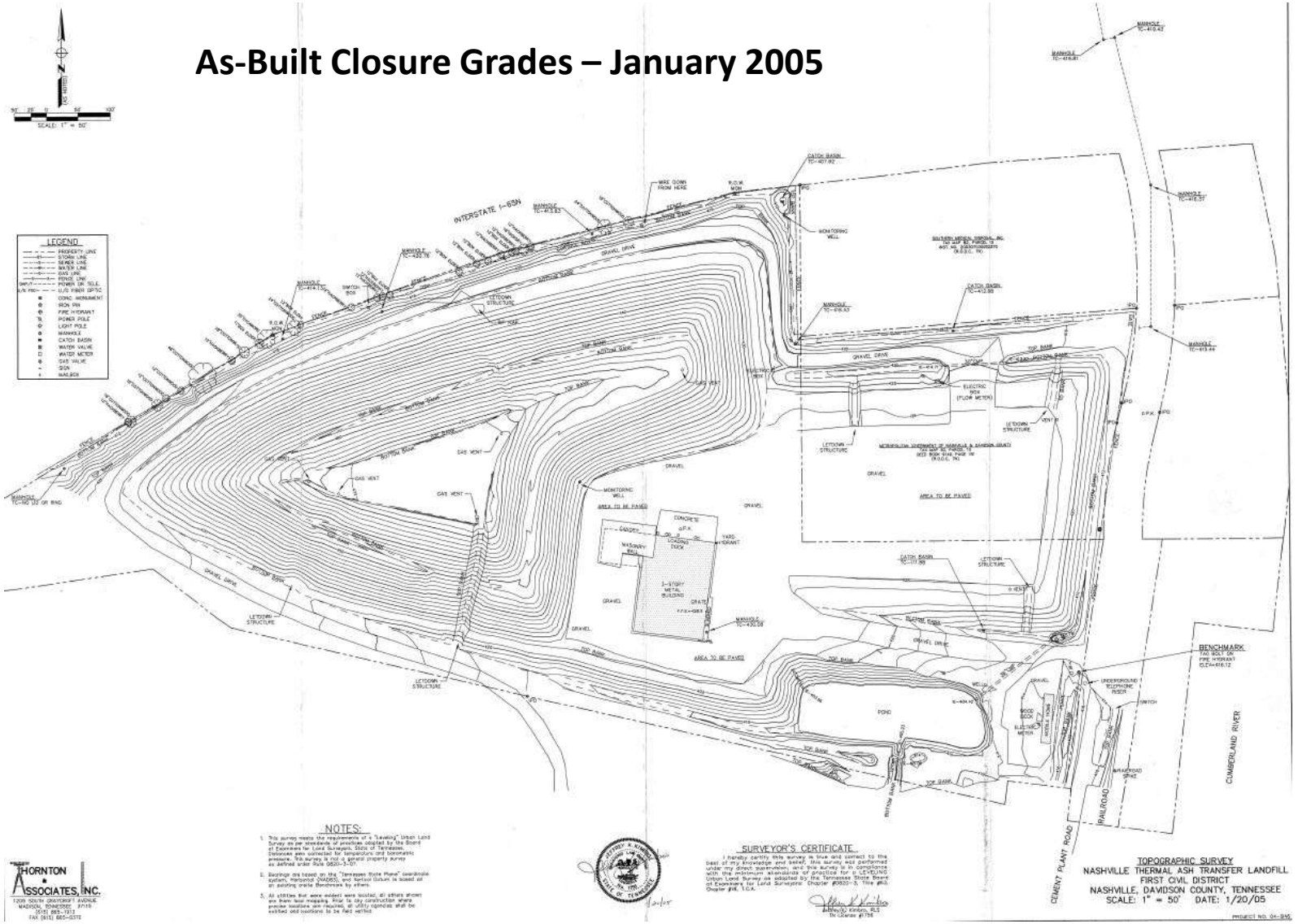
As-Built Closure Grades – January 2005



1Q 2010

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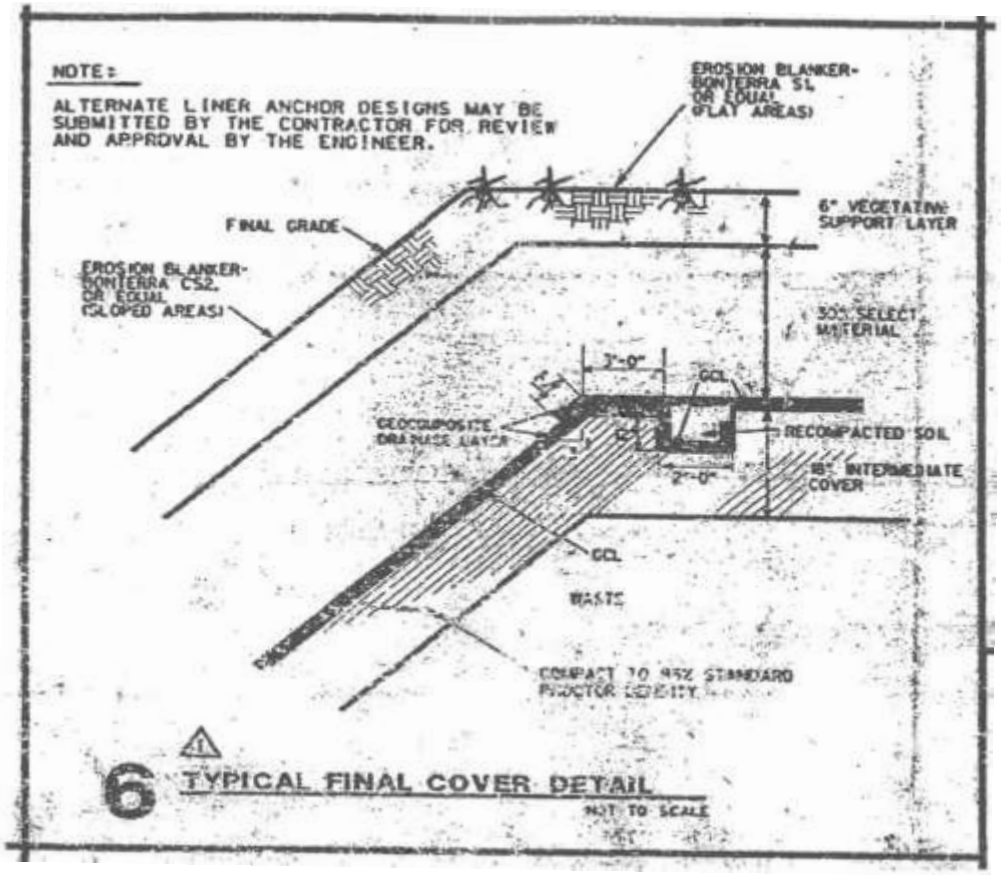

Reference: Drawing Titled, "Closure Plan for the Metro Thermal Ash Monofill", dated Sept 2002; Rev. January 2003, Prepared by Gresham Smith and Partners, Craig S. Parker, P.E.

Final Cover Design Configuration

- 3H:1V Sideslopes – low permeability soil (placed at k< 10^{-7} cm/s)
- Mid-Slope Benches (10’ width; 10:1 backslope – 1’ Bench Gutter) with Underdrains (4”Φ pipe/Stone/GT-S wrap)
- Three Letdown Structures (with Underdrains)
- Perimeter Drainage Channels(with Underdrains)
- Plunge Pools at Letdowns
- All flows to on-site Sediment Pond

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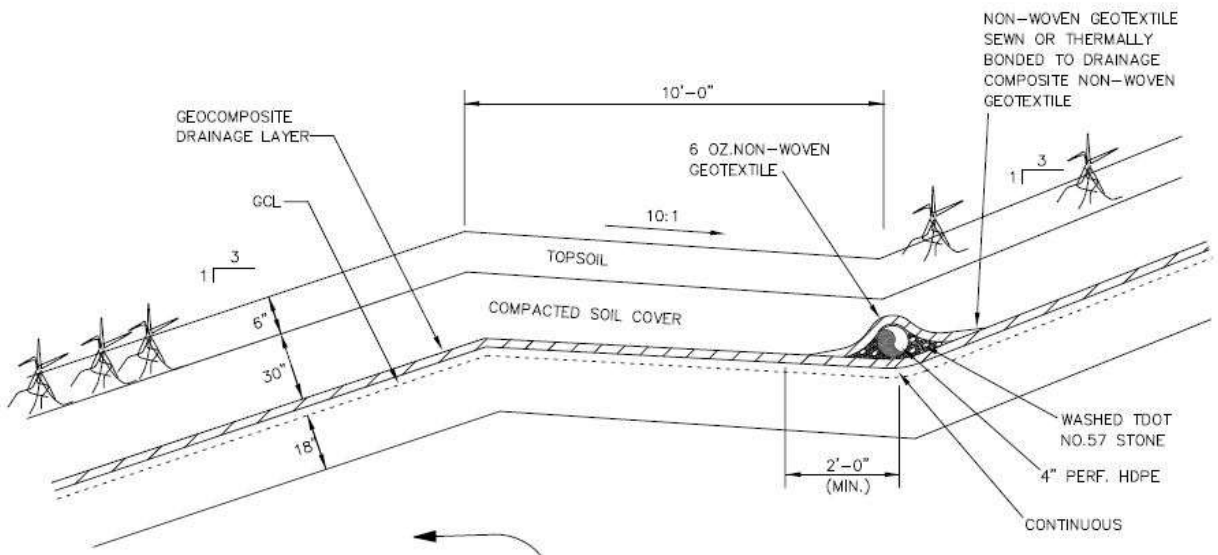

REFERENCE:
CONSTRUCTION DRAWINGS ENTITLED, "METRO THERMAL ASH MONOFILL CLOSURE," PREPARED BY GRESHAM SMITH AND PARTNERS, JUNE 2003, SHEET C.6, DETAIL 4.

METRO-DAVIDSON ASH MONOFILL GSP DESIGN DETAIL: BENCH	DRAWN BY: J.A.L.	CHECKED BY:	SCALE: N.T.S.	FIGURE NO. 3
	DATE: Sep. 2010	PROJECT NO. GSP 10-1	FILE NAME GSP-A0003	

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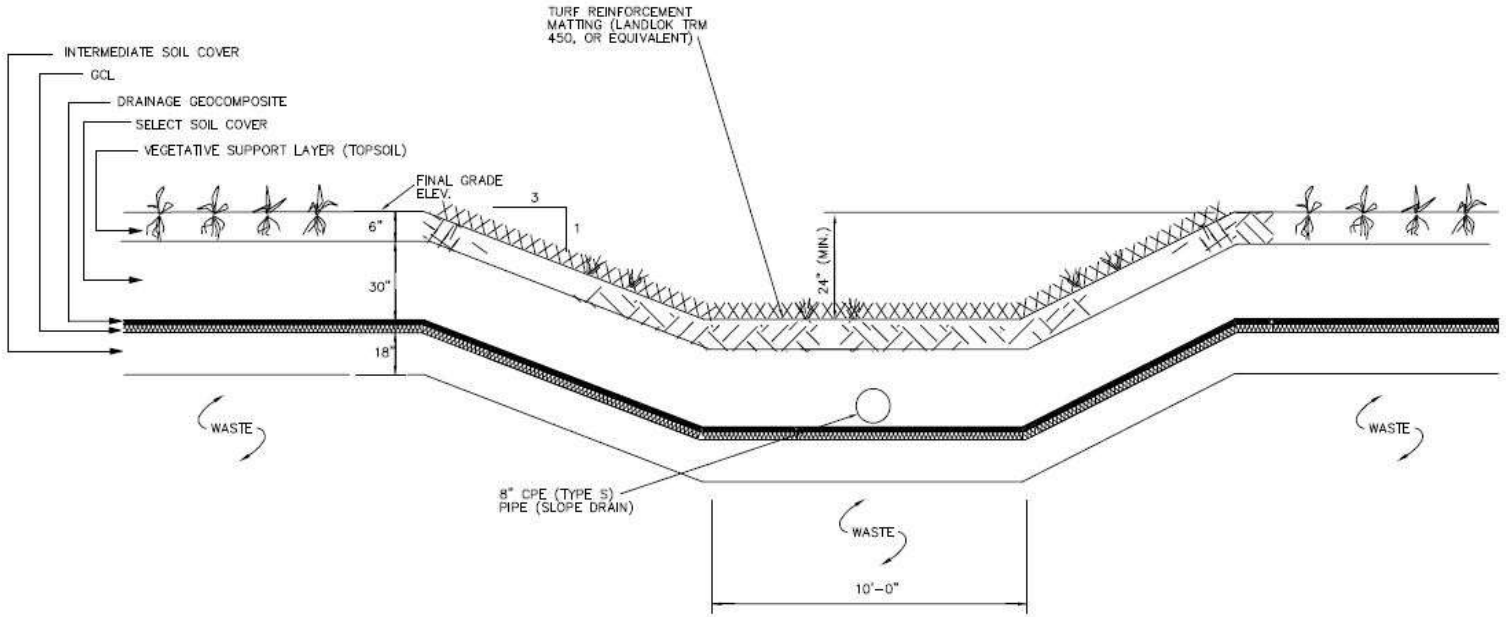

REFERENCE:
CONSTRUCTION DRAWINGS ENTITLED, "METRO THERMAL ASH MONOFILL CLOSURE," PREPARED BY GRESHAM SMITH AND PARTNERS, JUNE 2003, SHEET C.5, DETAIL 1.

METRO-DAVIDSON ASH MONOFILL GSP DESIGN DETAIL: LETDOWN STRUCTURE	DRAWN BY:	CHECKED BY:	SCALE:	FIGURE NO.
	J.A.L.		N.T.S.	4
	DATE:	PROJECT NO.	FILE NAME	
	Sep. 2010	GSP 10-1	GSP-A0004	

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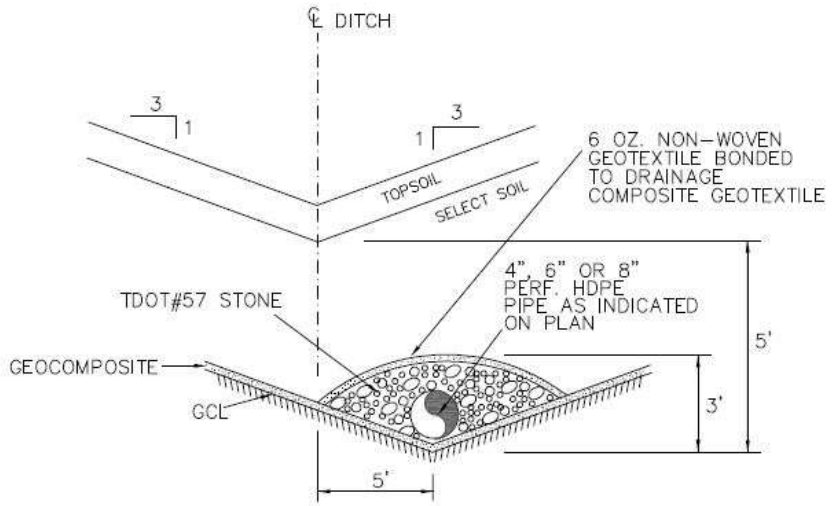

REFERENCE:
CONSTRUCTION DRAWINGS ENTITLED, "METRO THERMAL ASH MONOFILL CLOSURE," PREPARED BY GRESHAM SMITH AND PARTNERS, JUNE 2003, SHEET C.6, DETAIL 13.

METRO-DAVIDSON ASH MONOFILL GSP DESIGN DETAIL: PERIMETER UNDERDRAIN	DRAWN BY: J.A.L.	CHECKED BY:	SCALE: N.T.S.	FIGURE NO. 5
	DATE: Sep. 2010	PROJECT NO. GSP 10-1	FILE NAME GSP-A0005	

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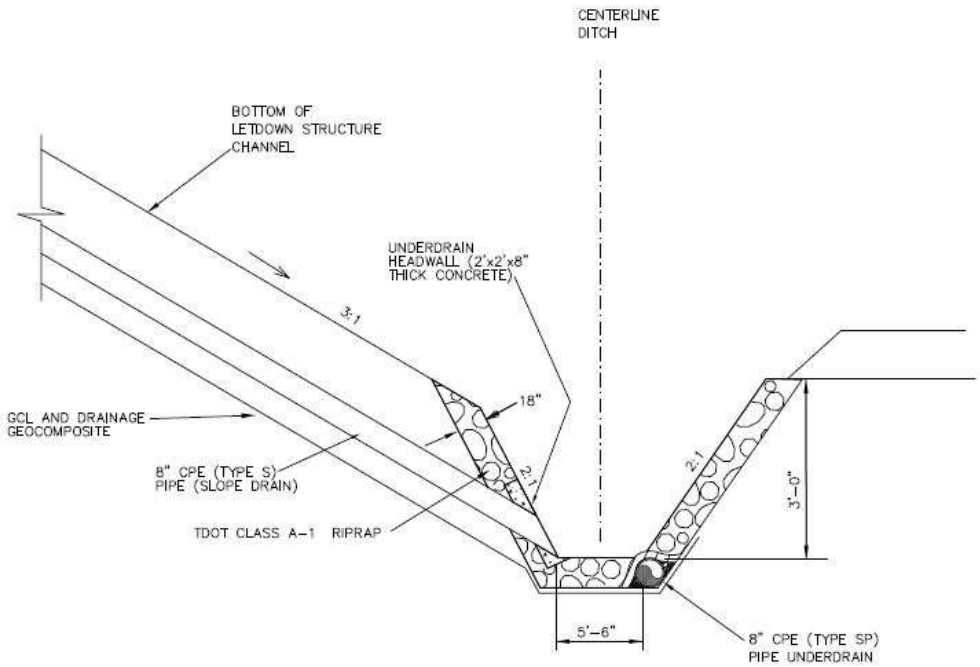

REFERENCE:
CONSTRUCTION DRAWINGS ENTITLED, "METRO THERMAL ASH MONOFILL CLOSURE," PREPARED BY GRESHAM SMITH AND PARTNERS, JUNE 2003, SHEET EC.4, DETAIL 6.

METRO-DAVIDSON ASH MONOFILL GSP DESIGN DETAIL: TYPICAL PLUNGE POOL	DRAWN BY:	CHECKED BY:	SCALE:	FIGURE NO.
	J.A.L.		N.T.S.	6
	DATE:	PROJECT NO.	FILE NAME	
	Sep. 2010	GSP 10-1	GSP-A0007	

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Weekend Rainfall Totals - May 1st & 2nd, 2010
Tennessee

Source: CoCoRaHS

0 25 50 100 150 Miles

Precipitation Contours

In inches

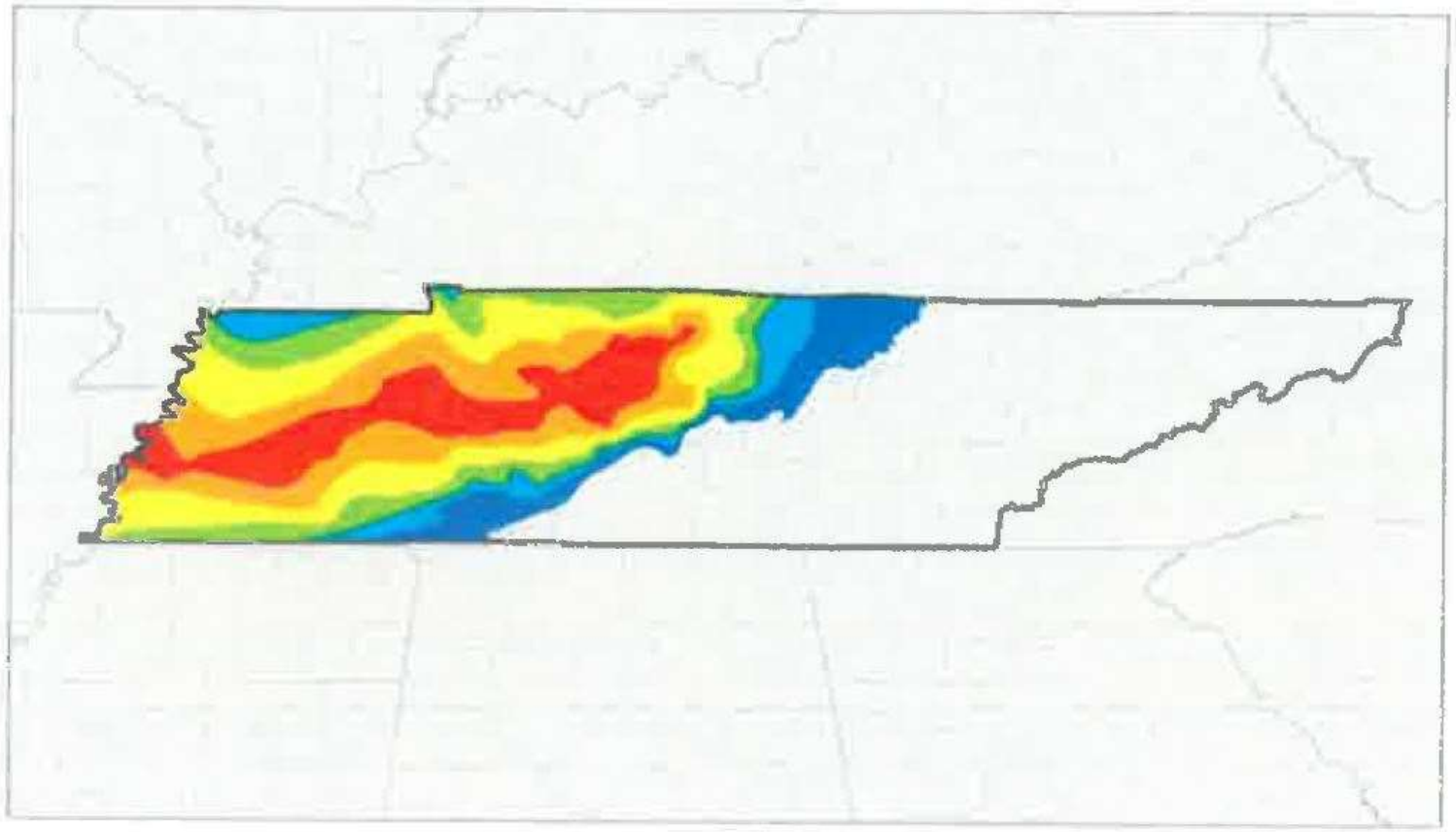
0.01" - 2.00"	8.01" - 10.00"
2.01" - 4.00"	10.01" - 12.00"
4.01" - 6.00"	12.01" - 14.00"
6.01" - 8.00"	14.01" - 16.00"
	16.01" - 20.00"

This map is an interpolation of actual reported values, but should be considered an estimation only.

Created by the National Weather Service Forecast Offices Nashville, Tennessee & Louisville, Kentucky

May 1, 2010 to May 3, 2010

- >13.4 " Rainfall at site (elsewhere 17" to 19.4 ")
- >1,000-Year/48-Hour event
- Site inaccessible until ~ May 5th
- New Record River Flood Levels across Middle TN


Tennessee Extreme Event of May 1-2, 2010
Average Recurrence Intervals (ARI) for 48-Hour Duration
Created by Hydrometeorological Design Studies Center
Office of Hydrologic Development
National Weather Service
National Oceanic and Atmospheric Administration
ARI (years)
< 10
10 - 50
50 - 100
100 - 200
200 - 500
500 - 1,000
> 1,000

May 3, 2010

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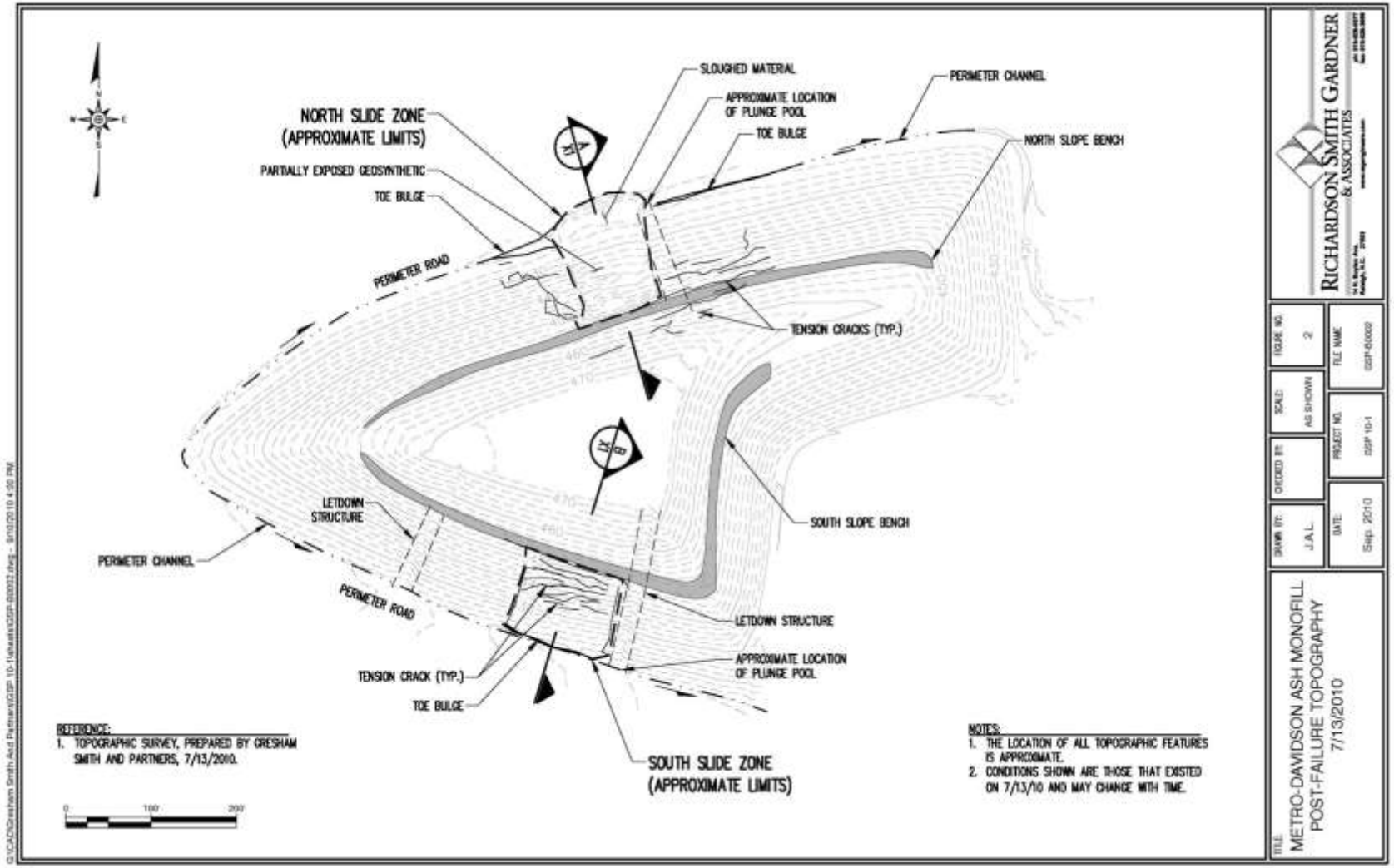

Photo 2. (North Slope) Scarp Immediately Down Slope from Bench

Photo 3. (North Slope) Scarp and Exposed Geocomposite

Photo 4. (North Slope) Crack and Letdown at East Side of Failure, Scarp at Top

Photo 5. (North Slope) Sloughed Cover Soil at Toe

Photo 6. (North Slope) Bulge at Toe

Photo 7. (South Slope) Bulge at Toe

Photo 8. (South Slope) Bulge at Toe

Photo 9. (South Slope) Tension Crack Below Bench

May 7, 2010 Conditions

- No intrusive/exploratory investigations “allowed” – just replace
- South & North Slopes impacted (~ 2 acres total)
- Significant material movement - North Slope only – DGC exposed
- Both areas: toe bulging & extensive upslope Tension Cracking
- Perimeter channels - flat bottom slopes/lower capacity
- No visible water flow in toe areas – although signs of significant water beneath North Slope Material
- Benches – flatter than designed and backslope less than designed
- Drainage Geocomposite and bench drain piping outlets - not visible

Analysis

Topographic Mapping Comparisons (2005 *&* 2010):

- North & South benches have similar slopes & capacities
- Perimeter Channels have flat slopes (North 0.4% avg) and South (1% avg) & low capacities
- Contributing watersheds – similar for each slide area

Analysis (Theorized)

Combination of Factors:

- Initial, small displacements due to toe saturation - progressed upslope – created T-cracks
- Mobilized shear strength along soil/DGC interface and within soil cover
- Progressive loss of frictional resistance along the soil/ geocomposite interface
  - Tension in upper DGC GT- S reduced “pillowing” friction
- Increase in downslope driving force - eventually exceeded buttressing
- Tension crack development - accelerated surface water to the geocomposite creating excessive head in the drainage geocomposite
  - Decreased normal load on soil/DGC interface
- Final Cover “floated” over the geosynthetics (North Slope only) - exposing DGC
- Excessive head was believed to be due to:
  - Loss in perimeter channel/underdrain capacity to drain the final cover drainage layer
  - Rate of flow into the drainage geocomposite
- Why North Slope Only? Differences in North and South slopes – none apparent, prior to construction

Factors (Theorized)

- Backwater in the plunge pools and Perimeter Channels contributed to inundate the upgradient perimeter underdrains on both slopes
- Critical movement occurred along the weakest un-reinforced interface (soil/drainage geocomposite)
- Critical movement did not occur along the DGC/GCL interface – due to tensile strength of the materials (anchored at the top of slope)
- Soils with high PI (33) increased susceptibility to shrink/swell (tension crack development)

Recommended Remediation

South Slide Zone (SubArea A):

- Regrade T-cracked slope areas and revegetate
- Provide a “break” in the bench drainage geocomposite (inspect underdrains)
- “Daylight” the drainage geocomposite into the perimeter channel through cap drain modification - disconnect from P. Underdrain
- Clean/reshape perimeter channel

Recommended Remediation

North Slide Zone (SubAreas B, C, D):

- Completely reconstruct the cap and drains subgrade to topsoil - (C only)
- Regrade T-cracked slope areas and revegetate (B, D)
- Provide a “break” in the bench drainage geocomposite (inspect underdrains) (B,C,D)
- “Daylight” the drainage geocomposite into the perimeter channel through cap drain modification - disconnect from P. Underdrain (B,C,D)
- Clean/reshape perimeter channel

FEMA Estimates/Site Inspections

(mid-May 2010 through June 2010)

- Cost Estimates (Time and unit price based)
- Site Interviews (2)

METROPOLITAN GOVERNMENT OF NASHVILLE AND DAVIDSON COUNTY
DEPARTMENT OF PUBLIC WORKS
NASHVILLE, TENNESSEE

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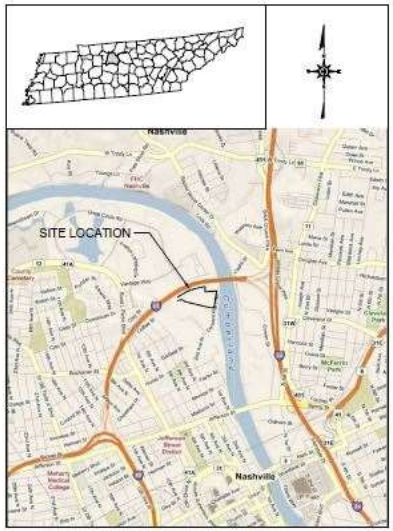
CAP RESTORATION CONSTRUCTION DRAWINGS

JUNE 2011

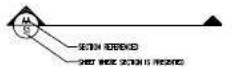


SITE LOCATION MAP
NOT TO SCALE

SHEET NO.	DRAWING NO.	TITLE	REVISION
1		TITLE – COVER SHEET	1
2	S1	EXISTING CONDITIONS (POST-FAILURE SURVEY)	1
3	S2	SITE RESTORATION PLAN	1
4	X1	SECTIONS (SHEET 1 OF 2)	1
5	X2	SECTIONS (SHEET 2 OF 2)	1
6	EC1	FINAL COVER AND EROSION CONTROL DETAILS (SHEET 1 OF 2)	1
7	EC2	FINAL COVER AND EROSION CONTROL DETAILS (SHEET 2 OF 2)	1

ISSUED FOR CONSTRUCTION

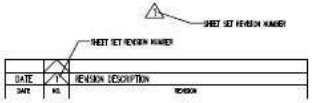
STANDARD SECTION LOCATION CALLOUT (SHEET AND DETAIL)



STANDARD DETAIL CALLOUT

STANDARD DETAIL LABEL AND CALLOUT

STANDARD REVISION CALLOUT (SHEET AND DETAIL)



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G S & P

SAFETY NOTE:
Contractor shall be solely responsible for initiating, maintaining and supervising all safety precautions and programs in connection with the Work. Contractor shall comply with all applicable Laws and Regulations relating to the safety of persons or property, or to the protection of persons or property from damage, injury, or loss; and shall erect and maintain all necessary safeguards for such safety and protection.

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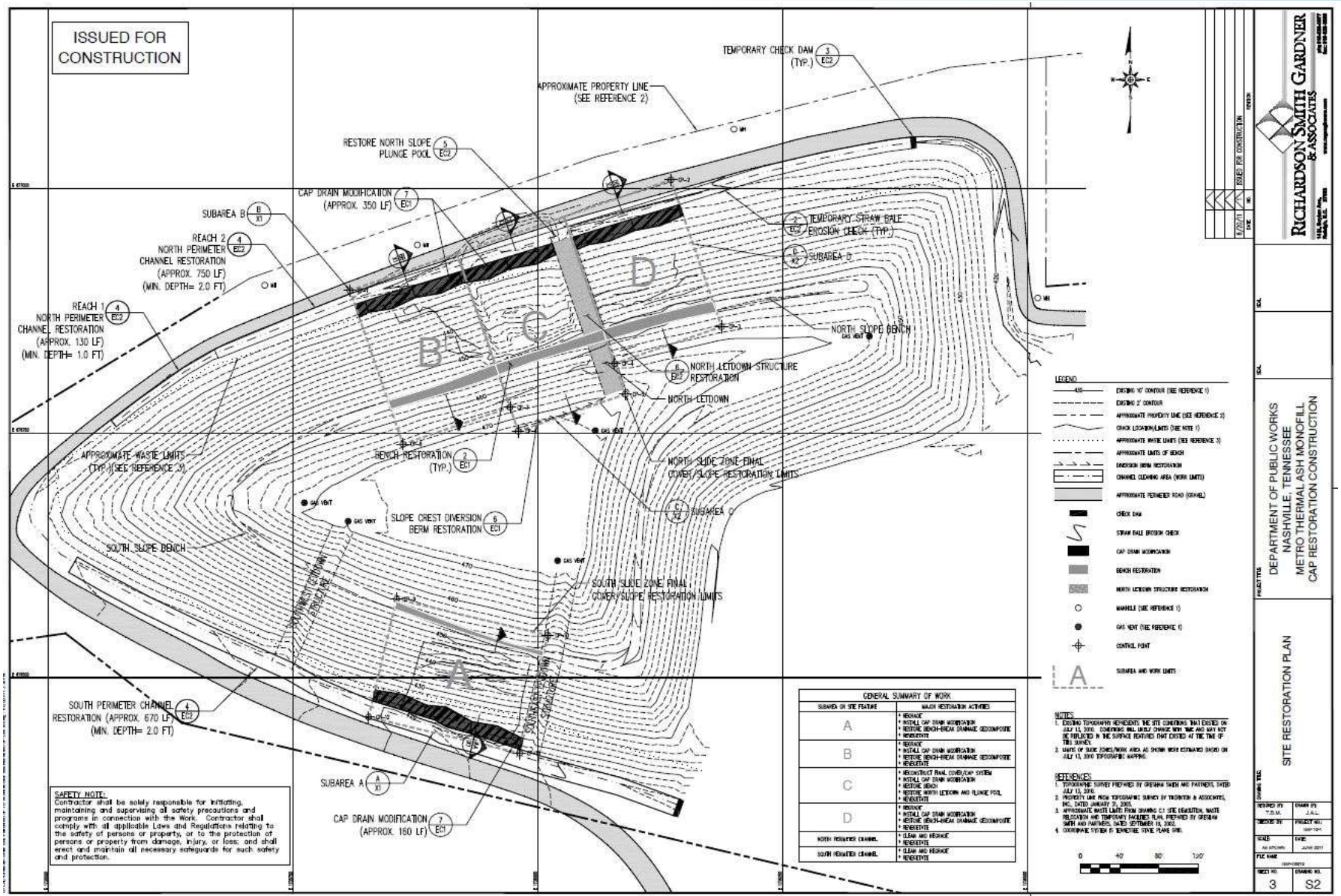

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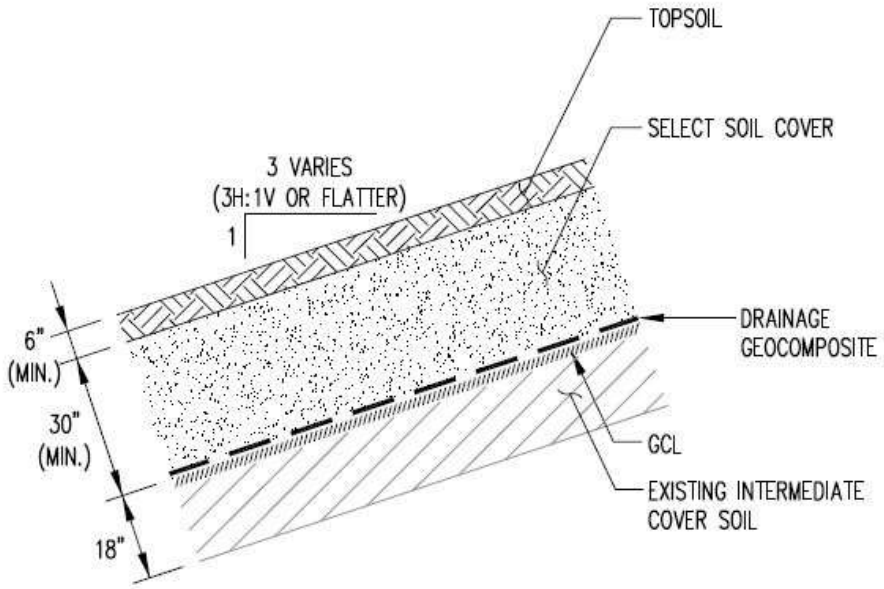

REFERENCE:
CONSTRUCTION DRAWINGS ENTITLED, "METRO THERMAL ASH MONOFILL CLOSURE," PREPARED BY GRESHAM SMITH AND PARTNERS, JUNE 2003, SHEET C.6, DETAIL 6.

FINAL COVER SECTION

DETAIL 1 / EC1

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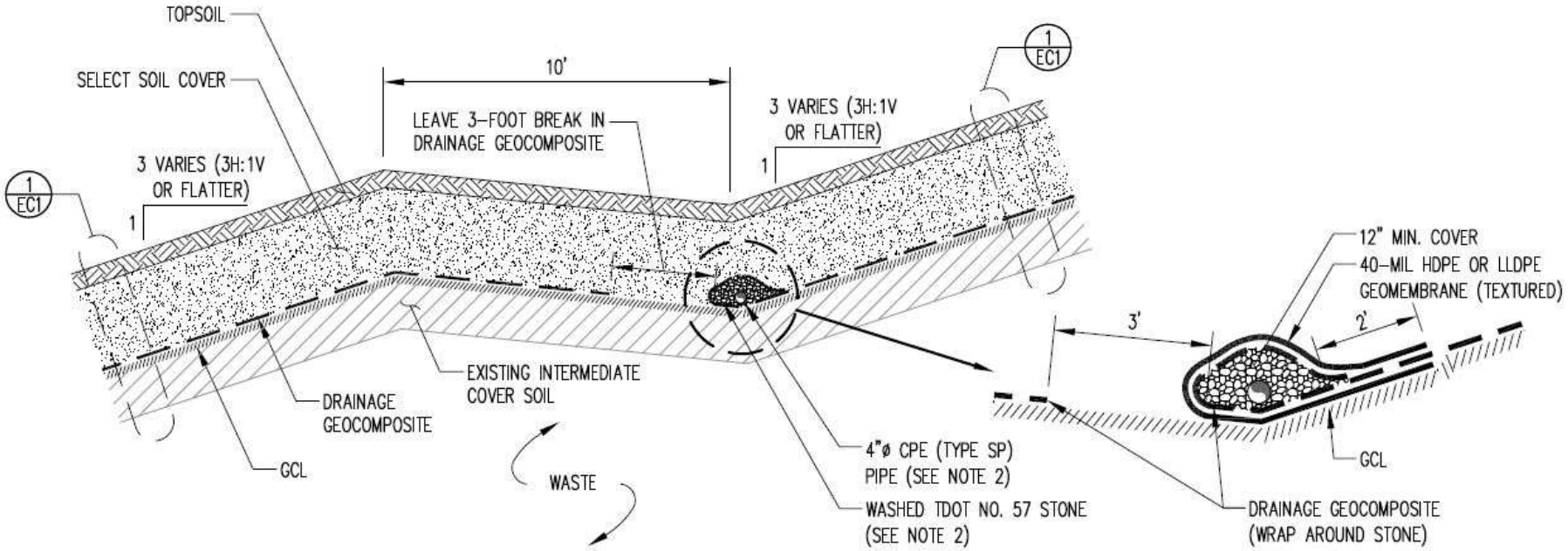

BENCH RESTORATION

DETAIL 2 / EC1

NOT TO SCALE

NOTES:

1. TRANSVERSE TERRACE SLOPE SHALL BE 1% MIN. TO LETDOWN STRUCTURE.
2. WRAP GEOCOMPOSITE AND STONE/PIPE IN 40-MIL HDPE OR LLDPE (TEXTURED) GEOMEMBRANE.

REFERENCE:

1. DETAIL (BEFORE MODIFICATION) IS TAKEN FROM CONSTRUCTION DRAWINGS ENTITLED, "METRO THERMAL ASH MONOFILL CLOSURE," PREPARED BY GRESHAM SMITH AND PARTNERS, JUNE 2003, SHEET C.6 DETAIL 4.

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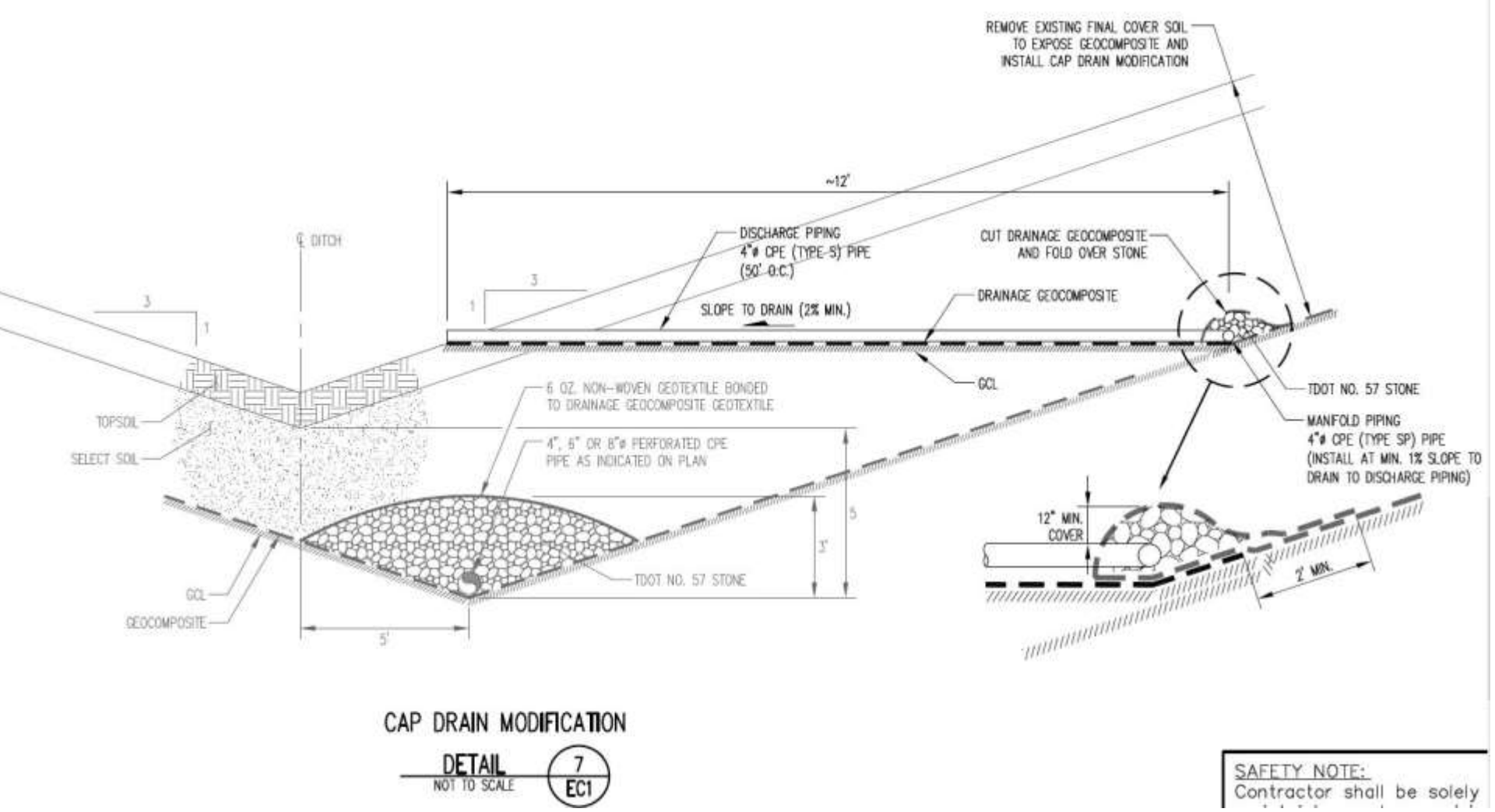

CAP DRAIN MODIFICATION

DETAIL 7 / EC1

NOT TO SCALE

SAFETY NOTE:
Contractor shall be solely

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Grading Subarea-A

Exposing Bench Drain pipe Subarea-A

Excavation for Cap Drain Modification, Subarea-A

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Subarea-A, bench restoration, looking southeast

Removing vegetative layer, Subarea-B

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Exposed Bench Drain, top of slope, Subarea-B

Subarea-B, completeing bench restoration

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Subarea-B, completed bench restoration. Backfilled bench, added topsoil

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Cutting in slope for cap drain modification, Subarea-B, looking east

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Subarea-C, Removing cover material to expose liner over entire slope

Subarea-C, underdrain in eastern let-down structure

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Subarea-C, Removing cover material to expose liner in bench

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Subarea-C, deploy GCL panels

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Subarea-C, GCL deployment

Subarea-C, sand placement over GCL

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Subarea-C, drainage composite in anchor trench

Subarea-C, bench restoration

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Subarea-C, letdown underdrain

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Subarea-C, soil cover placement

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Subarea-C, drainage composite deployment

Subarea-C, zip tie drainage composite

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Subarea-C, toe drain construction

Subarea-C, toe drain construction

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Subarea-C, cap drain modification construction

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Subarea-C, soil cover placement over cap drain modification

Subarea-C, underdrain coming from Subarea-D

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Subarea-C, underdrain coming from Subarea-D

Subarea-C, final grading

Subarea-C, seed and straw placement

North perimeter channel placement

Subarea-C, letdown structure

North letdown structure, plunge pool

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Subarea-C, top of landfill

Subarea-C straw, access road gravel placed

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Subarea-D, removing vegetative layer

Exposing Bench Drain, top of slope, Subarea-D, looking west

Subarea-D, exposed composite in toe of slope soil bulge, close up

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Subarea-D, locating underdrain, edge of drainage composite exposed

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Subarea-D, locating underdrain pipe, pipe out of subgrade ditch, standing water where pipe should be in ditch

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Regrading Subarea-D

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Subarea-D, bench restoration

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Subarea-D, completed bench restoration. Backfilled bench, added topsoil

Subarea-C, soil boring 2 depth

Key Findings During Construction

- Perimeter Toe Drain in SubArea C/D was crushed (~ 120 LF)
- Perimeter Toe Drain in SubArea D was mis-located (i.e. not in the low point) and not perforated.

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Restored Slope As-Built – November 2011

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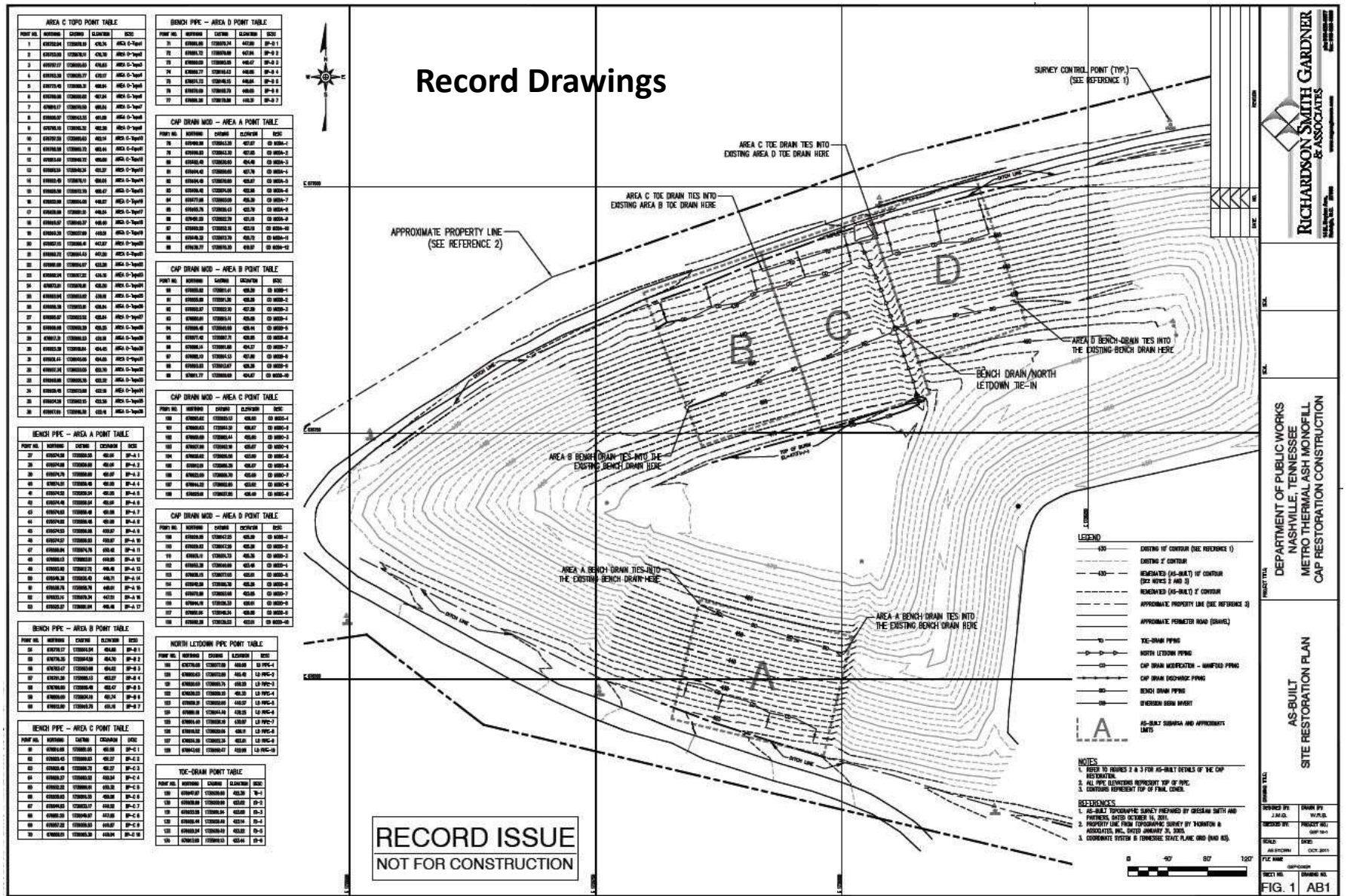

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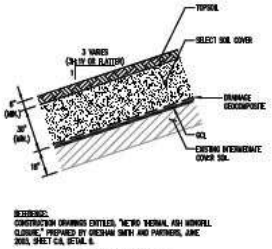
RECORD ISSUE
NOT FOR CONSTRUCTION

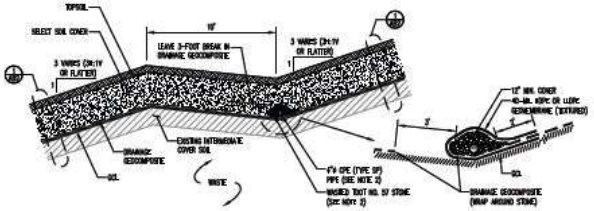
Record Drawings

CONSTRUCTED ACCORDING TO DETAIL



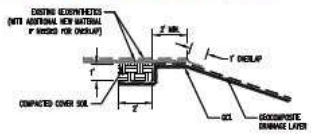
FINAL COVER SECTION
AS-BUILT — DETAIL 1 / AB2

CONSTRUCTED ACCORDING TO DETAIL

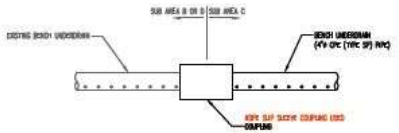


BENCH RESTORATION
AS-BUILT — DETAIL 2 / AB2

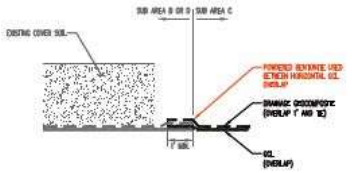
CONSTRUCTED ACCORDING TO DETAIL



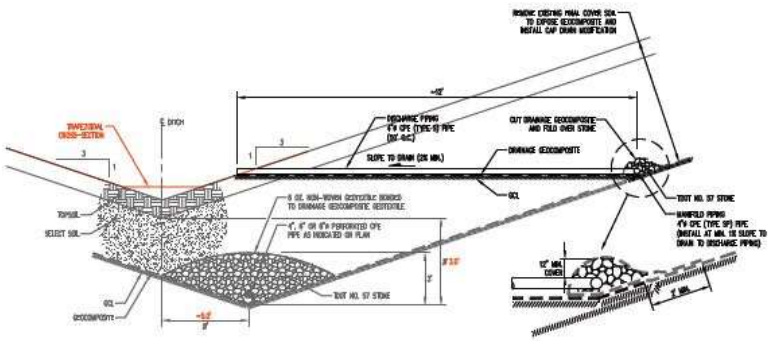
ANCHOR TRENCH
AS-BUILT — DETAIL 3 / AB2



BENCH UNDERDRAIN TIE-IN
AS-BUILT — DETAIL 4 / AB2

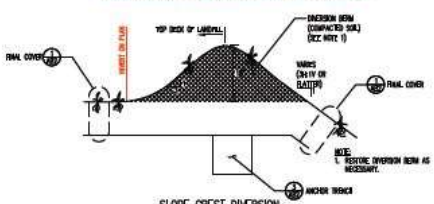


GEOSYNTHETIC TIE-IN
AS-BUILT — DETAIL 5 / AB2



CAP DRAIN MODIFICATION
AS-BUILT — DETAIL 7 / AB2

CONSTRUCTED ACCORDING TO DETAIL



SLOPE CREST DIVERSION
AS-BUILT — DETAIL 6 / AB2

NOTE:
1. AS-BUILT INFORMATION PROVIDED BY RSC/GRESHAM SMITH AND PARTNERS, SHOWN IN RED.

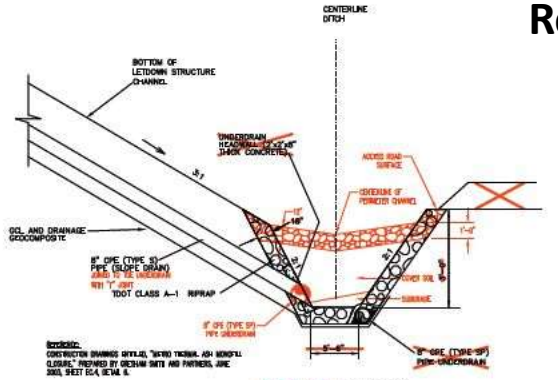
RICHARDSON SMITH GARDNER & ASSOCIATES

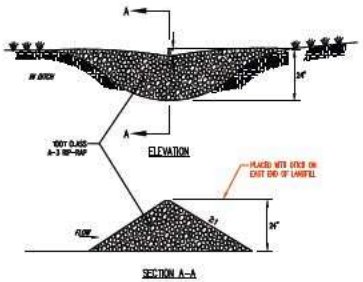
PROJECT TITLE:
DEPARTMENT OF PUBLIC WORKS
NASHVILLE, TENNESSEE
METRO THERMAL ASH MONOFILL
CAP RESTORATION CONSTRUCTION

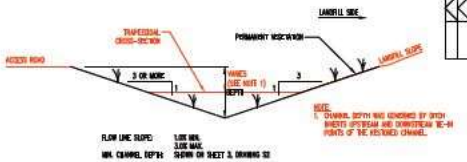
DRAWING TITLE:
AS-BUILT - FINAL COVER AND EROSION CONTROL DETAILS (SHEET 1 OF 2)

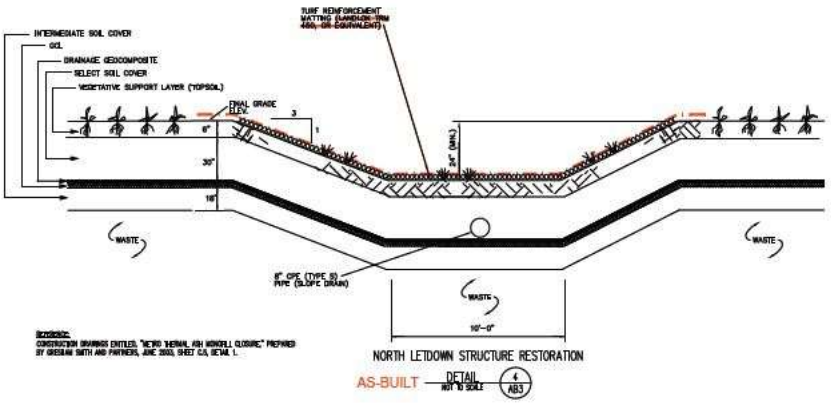
DESIGNED BY: J.M.G. | DRAWN BY: J.A.L.
CHECKED BY: | PROJECT NO.:
SCALE: AS SHOWN | DATE: DEC. 2013
FILE NAME:
SHEET NO.: FIG. 2 | DRAWING NO.: AB2

Record Drawings









RECORD ISSUE
NOT FOR CONSTRUCTION

NOTE:
1. AS-BUILT INFORMATION PROVIDED BY RSG/GRESHAM SMITH AND PARTNERS, SHOWN IN RED.

RICHARDSON SMITH GARDNER & ASSOCIATES

DEPARTMENT OF PUBLIC WORKS
NASHVILLE, TENNESSEE
METRO THERMAL ASH MONOFILL
CAP RESTORATION CONSTRUCTION

AS-BUILT - FINAL COVER AND EROSION CONTROL DETAILS (SHEET 2 OF 2)

DESIGNED BY: J.M.G. DRAWN BY: J.A.L.
CHECKED BY: PROJECT NO.: GSP-10-1
SCALE: AS SHOWN DATE: DEC 2010
FILE NAME: GSP-C0029
SHEET NO. FIG. 3 DRAWING NO. AB3

Post – Remedial Construction
2012 to Present

2014 Aerial

Discharge end of Cap Drain Modification Piping

Possible Culprits

OR

South Slope July 2012

South Slope Cracks – July 2012

South Slope Cracks – August 2012

South Slope Cracks – September 2012

South Slope - 2016

South Slope - 2016

North Slope - 2016

North Slope - 2016

Take-Aways:

1. Good (perimeter) drainage is critical.
2. There is a storm coming that will exceed your design and impact even “good” final cover designs.
3. Redundancy in final cover designs is needed
4. Post-closure monitoring/inspection & maintenance is never finished